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Inventorying the Molluscan Diversity of the World: What Is Our Rate of Progress?

by

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Abstract. Levels and trends in the naming of new mollusk species over the last 30 years are reviewed through analysis of a sample of 12,561 names extracted from nine volumes of Zoological Record. On average, 1395 new species-group mollusks are being named each year, of which 69% are fossils (average yearly increment: 366 Recent gastropods, 292 fossil gastropods, 42 Recent bivalves, 316 fossil bivalves, 320 fossil cephalopods, and 59 other Recent and fossil mollusks). Using a smaller sample of 1996 names, the synonymy ratio of Recent taxa is calculated to be 1.6, i.e., about 265 new valid species are named each year. Over the past 25 years, the number of new marine species described each year has increased by 68%, whereas the number of new non-marine species has decreased by 15%. The most significant decrease concerns tropical continental faunas. Possibly as many as half of the new descriptions of Recent species are by people not funded for this purpose, with amateurs authors of 28% of the descriptions. The United States has the most active scientific professional and non-professional community, being responsible for over 20% of new Recent species. Nearly half of the new species worldwide are described in malacological journals. With a collecting effort of marine mollusks increased by several orders of magnitude in the last few decades, there is no sign of leveling off in the inventory of molluscan diversity. For the foreseeable future, micromollusks, the deep-sea, and the marine and non-marine tropics will remain effectively inexhaustible reservoirs of undescribed species. From a conservation perspective, the loss of knowledge of and attention to tropical land and freshwater faunas is dramatic, considering loss of habitat and extinction.

INTRODUCTION

In this age of shrinking natural habitats and an unprecedented extinction crisis (Ehrlich, 1995), biodiversity has become a buzzword of grant applications and conservation programs. The baseline for all biodiversity studies is an inventory of the species that inhabit this planet and where they live, a goal that has been championed by projects such as Systematics Agenda 2000 (Anonymous, 1994). Whereas birds, and to a lesser extent mammals, are now virtually completely inventoried, the diversity of invertebrates is still far from being adequately surveyed. A significant part of malacological research effort continues to involve alpha-taxonomy and descriptions of new species.

In the present paper, I address the question of how malacologists are achieving the goal of global species inventories? Which areas of the world are receiving most, and least, attention? Which national communities are most active in this research effort? I first address these questions through a quantitative analysis of descriptions of new species. In a more qualitative approach, I summarize what have been the major fronts in the last decades. In conclusion, I discuss where I believe our efforts should go to in the next few decades.

METHODS

I have used the *Zoological Record* (hereafter *ZR*) to extract data on descriptions of new species-group taxa, their geographical and stratigraphical location, and the type of publication outlet containing the description. As a representation of research activity, I have sampled sets of 2 consecutive years in the 1960, 1970, 1980, and 1990 decades, as they are recorded by *ZR*: volumes 104 (1967) and 105 (1968); volumes 114 (1977) and 115 (1978); volumes 124 (1987) and 125 (1988); volumes 129 (1992) and 130 (1993). The year 1978 was found to deviate anomalously (and inexplicably) from other years in having a considerably higher number of fossil species described, therefore data were researched for *ZR* volume 116 (1979) to balance, if necessary, the effect of 1978.

I am here using the word species as an equivalent of

Table 1

Numbers of new species of Recent and fossil mollusks described during 9 sample years. Source: Zoological Record.

	Fossil	Recent	Total
1967	1102	396	1498
1968	682	346	1028
1977	828	406	1234
1978	1792	525	2317
1979	1352	327	1679
1987	671	457	1128
1988	809	504	1313
1992	820	376	1196
1993	635	533	1168
Total 9 years	8691	3870	12,561
Average/year	965.5	430	1395.5

Table 2

Average numbers of new fossil and Recent mollusks described yearly (for 9 sample years, 1967–1993), partitioned by class.

	Fossil	Recent	Total
Aplacophora	—	10	10
Monoplacophora	9.5	0.7	10.2
Polyplacophora	2.1	6.2	8.3
Cephalopoda	320.4	3.9	324.3
Scaphopoda	2.9	1.5	4.4
Bivalvia	315.8	41.9	357.7
Gastropoda	292	365.8	657.8
Other classes*	22.8	—	22.8
Total	965.5	430	1395.5

* Rostroconchia, Hyolitha, Tentaculita.

the species-group category (i.e., my counts include new subspecies as well as species), but they do not include *nomina nova*, since these represent the result of nomenclatural rather than taxonomical discoveries. Subspecies account for between 3 and 10% of all new species-group names, depending on the year considered. There are at least two problems with this approach: (1) Each volume of *ZR* records not only papers and names published during the nominal year for that volume, but also a number of names omitted from earlier volumes. However, it is assumed that all volumes are affected in the same way and represent the scientific output of equivalent periods of time; (2) It has been demonstrated elsewhere (Bouchet & Rocroi, 1992) that the coverage of new supraspecific names by *ZR* misses about 23% of the names. I have not tried here to evaluate an omission rate for species-group names, but it is safe to assume that it is not negligible. Based on my experience with genus-group names, omission appears to affect considerably more fossil than Recent taxa. Since much of the present paper deals with data on Recent mollusks, I believe that my results are valid within an acceptable margin of error.

RESULTS

Naming New Molluscan Species

Numbers of new Recent and fossil species are tabulated separately for each of the 9 years sampled (Table 1). For each of the major classes, the distinction between Recent and fossil taxa is tabulated separately (Table 2), the 9 study years being pooled together. A number of results emerge from the tables:

(1) During the last 30 years, the average yearly output stands at 1395 new species (366 Recent gastropods, 292 fossil gastropods, 42 Recent bivalves, 316 fossil bivalves, 320 fossil cephalopods, and 59 other Recent and fossil mollusks). This average has remained remarkably stable over the last 3 decades. In 7 years out of 9, the number of new species described ranges between 1000 and 1500.

(2) Fossils account for 69.2% of the new species, with individual values ranging from 54.3% (1993) to 80.5% (1979). The high number of fossils is caused to a large extent by fossil cephalopods: these alone account for one-third of all new fossil species and for 23% of all new mollusk species. Also, 88.3% of all new bivalves are fossils. The proportion between fossil and Recent is more balanced in gastropods: only 44.4% of all new gastropods are fossils.

(3) The average number of new Recent species stands at 430 per year. Despite much variance in the data concerning successive years, it appears that the average has slowly but regularly increased: it stood at 371 per year in the 1960s, rose to 419 in the 1970s, and has reached 467.5 in the last 10 years. This increase is not paralleled in fossils, with results for individual years showing still more variance. There was an unexplained peak in the 1970s (1324 per year), and the number of new fossil species has in the last 10 years reached a level well below the 1960s average (734 vs. 892 per year, respectively).

Where Do the New Species Come from?

The slow increase in naming of new Recent mollusk species since the 1960s masks two different trends (Figure 1). Marine mollusks, which in the 1960s accounted for 184.5 new species per year, or 49.7% of the total of Recent species, in the last 10 years (1987–93) accounted for 310.5 new species or 66.4% of the total. By contrast, non-marine mollusks slipped from 186.5 new species in the 1960s to 157 in the last 10 years. The global increase in naming activity noticed above therefore results from a steep increase in the naming of marine mollusks (+ 68% in 25 years) and a recession (−15.8%), or at best a stagnation, in the naming of non-marine mollusks.

The proportions for individual biogeographical regions are rather erratic from decade to decade (Table 3; Figure 2). The Indo-Pacific and the Caribbean account respectively for 34.5% and 16% of all new marine mollusks. The Panamic and West African tropical regions account for 7% each, but they have followed different trends since the

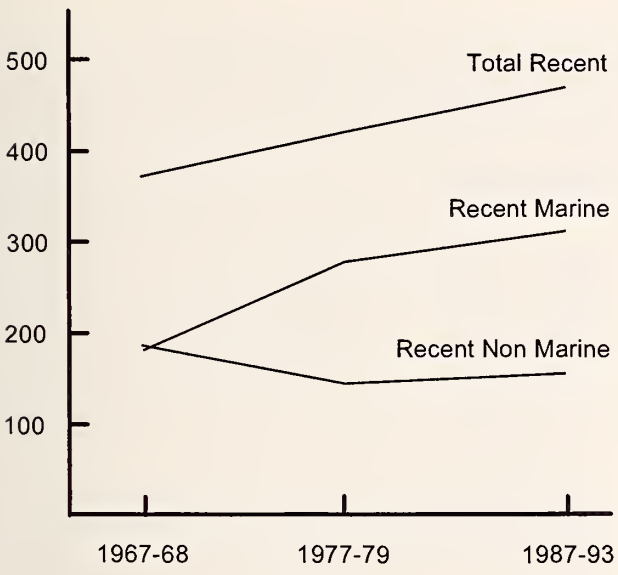

Figure 1

The number of new Recent species described yearly over the last 30 years.

1960s. The Panamic region dropped from 11.1% (1967–1968) to 3.9% (1992–1993), while West Africa was increasing from 3.8% (1967–1968) to 12.3% (1992–1993). Another possibly significant trend is discernible in Europe, which has dropped from a peak 16.3% in the 1970s to just 4.3% in 1992–1993. The figures for the other regions may

Table 3

Partitioning of new Recent mollusks to major biogeographic regions. Weight of individual regions indicated as percentage of total within discrete time periods. Total number of names involved in italics.

	1967–68	1977–79	1987–88	1992–93
Indo-Pacific	38.7	36.3	22.9	43
North Pacific	7.9	2.5	2.9	4.8
S. Australia/N. Zealand	11.9	8	6.3	1.4
Panamic	11.1	8.4	5.4	3.9
South Africa	1.4	2.8	11	6.4
West Africa	3.8	5.2	6	12.3
Europe	6.2	16.3	10.4	4.3
Caribbean	13.8	7.5	27.3	16.4
Antarctic	—	9.8	0.3	1.4
Other	5.1	3.2	7.5	5.9
Total marine	*369*	*828*	*682*	*560*
Palearctic	27.6	39.5	53.4	37.8
Nearctic	5.4	7.4	23.7	1.4
Neotropical	23.9	14.2	6.1	4.9
Africa	11.3	9.8	6.1	15.2
Australia-Pacific	6.4	25.3	5.7	34.7
Oriental	25.5	3.7	5	6
Total non-marine	*373*	*430*	*279*	*349*

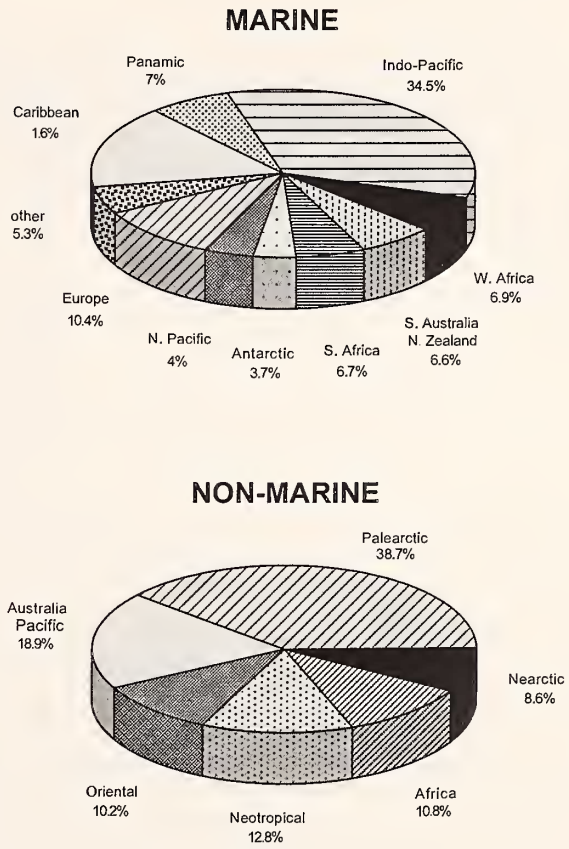

Figure 2

Partitioning of new Recent mollusks to major biogeographic regions. Percentages calculated globally for the period 1967–1993, based on data in Table 3.

not be significant as they probably reflect the much smaller number of malacologists involved in their study.

The results for non-marine mollusks also exhibit much variance, but some tendencies can possibly be discerned (Table 3; Figure 2). In the 1960s, the Palearctic, Neotropical, and Oriental regions each accounted for one-fourth of the total effort. Since then, the Palearctic is the only region which has experienced a regularly high output of descriptions, surpassing well over 25% of the total for any period of time considered. Conversely, the proportions occupied by the Neotropical and Oriental regions have collapsed well below 10% each. The only tropical region which may possibly have experienced an increased research effort is the Australasia-Pacific.

New Species and Synonyms

How many of the species described as new were really new, and how many will end up as synonyms of already named species? Because there are usually very few specialists working simultaneously on any given family or geographical region, there are few, if any, taxonomists that can provide an expert opinion on the validity of a new

Table 4

Synonymy ratio of new nominal species described in the last decades for selected samples.

Sample	Period	No. nominal species	No. valid species	Synonymy ratio	Source
Eulimidae	1965–1995	173	167	1.04	Warén, personal communication
Muricidae	1972–1993	384	316	1.22	Houart, 1994
Volutidae	1960–1992	116	82	1.41	Poppe & Goto, 1992
Terebridae	1960–1985	65	49	1.33	Bratcher & Cernohorsky, 1987
Conus	1965–1994	164	81	2.02	Röckel et al., 1995
European marine mollusks	1967–1995	1094	539	2.03	Gofas & Le Renard, personal communication
Total		1996	1234	1.62	

species immediately after it has been described. Synonymization usually occurs in the context of genus or family revisions. Such revisions may occur many years after the description of a new species (Solow et al. (1995) estimate that it takes on average 43 years to identify a synonym in the Thysanoptera). It is therefore too early to quantify globally the validity of new species described in the last 3 decades. I have however tried to approach the synonymy ratio [= number of names/number of valid taxa] based on selected samples (Table 4). My sources are published revisions as well as unpublished information in the CLEMAM database on the European marine mollusks (Gofas & LeRenard, personal communication) and a catalogue of taxa in the family Eulimidae (Warén, personal communication). The result is a synonymy ratio of 1.62, based on a sample of 1996 names. My feeling is that the sample used leads to an overestimation of the number of synonyms because, with the exception of Eulimidae, it concerns taxa or regions where a high number of authors are involved. They are also taxa, again with the exception of Eulimidae, where many species have commercial value as "specimen shells." As a consequence, competition among authors is high, and there are numerous examples of a new species being described almost simultaneously by competing authors, or being described without proper research in an attempt to win priority. In the vast majority of land and freshwater mollusks or marine micromollusks, this competition does not occur, but as a consequence, the validity of recently described taxa has not yet been evaluated. Therefore, for lack of a better approximation, I keep 1.62 as a working figure. If this ratio is projected over the average number of new species (430) described each year, we find that 265 valid new species are added each year to the inventory of molluscan diversity. Based on a different data set (i.e., all the names proposed since Linnaeus for selected groups of bivalves and gastropods), Boss (1971) calculated a synonymy ratio of 4, i.e., three synonyms for every valid species. My results thus confirm the opinion of Solem (1978) who had criticized Boss' synonymy ratio as being too high, and suggest that at least 62% of the new species described in the last 30 years were indeed new species. In fact, my result is remarkably close to that of Solow et al. (1995), who estimated that the proportion of valid species in the Thysanoptera is around 61%.

Table 5

Number of authors and co-authors involved in the naming of new Recent mollusks.

Year	No. authors	No. names
1977	114	406
1978	100	525
1992	177	376
1993	159	533

Who Describes?

I have studied two samples (1977–1978 and 1992–1993) to quantify the descriptive effort by author and by country. Table 5 shows that the number of authors involved in naming new Recent mollusk species has increased over the last 15 year period. For the most recent sample (1992–1993), a total of 284 authors named 909 species. One hundred and twenty-five authors (44%) were involved in 1992 only, and 107 authors (37.7%) in 1993 only, and just 52 authors (18.3%) were involved in each of these 2 consecutive years.

I then counted the number of new species described by authors from different countries. In doing so, I considered the nationality of an author to be that of the country where he/she works, not that of his/her birth. In the case of co-authored new species, I have credited each author with one-half, one-third, etc. of the number of co-authored names. Not unexpectedly, the result (Table 6) shows that USA is the most productive country, with over 20% of the new species. Germany, Japan, Netherlands, and Belgium have also had a stable and steady output over the last 15 years. The output of other countries has varied considerably. Some of this variation may reflect real trends, but it may also reflect the inadequacy of the data set, especially when it involves single large papers from countries with few

malacologists. In the case of the former Soviet Union, the observed trend may reflect diminished resources for taxonomists as a result of political changes. It is noteworthy, and regrettable, that mega-diversity countries such as Mexico, Brazil, India, Indonesia, the Philippines, and China have such a low profile on the international scene of molluscan species inventorying, none of them contributing more than 1% of the global descriptive effort.

Descriptive malacology is but a small field of zoology and a still smaller field of biology. I have thus compared the malacological ranking of countries with their ranking based on publication counts extracted from the 1989–1993 annual cumulations of the Science Citation Index (Braun et al., 1995), a scientometric index that privileges mainstream journals and ignores many journals published by institutions and amateur societies. I have used the ranking for General Biology, which includes the subject categories Biology, Biophysics, Botany, Entomology, Ornithology, Parasitology, and Zoology. The comparison (Table 6) shows that Austria, Belgium, Germany, Netherlands, New Zealand, and South Africa have a higher weight in descriptive malacology than in "general biology" as defined above. Conversely, the USA and United Kingdom have a much higher scientometric weight than their output in descriptive malacology indicates. It is remarkable that Canada ranks number 4 in terms of scientometric weight, but has a negligible output in the field of descriptive malacology.

Malacologists may describe new species from their own biogeographical region (an activity that may be qualified as "internal") or from more distant regions (an activity that may be qualified as "external"). It is interesting to note that much of the research by malacologists from Europe (including ex-USSR) and the United States is external (Figure 3), whereas it is mainly internal in Australasia, Japan, and the rest of the world. These data suggest that taxonomists in Europe and the United States judge, correctly or incorrectly, that their faunas are adequately inventoried and turn to other parts of the world to discover new mollusks.

The vast majority of papers contain the descriptions of only one or two new species. Of 320 articles that were published in 1992–1993, 193 (60.3%) contain the description of a single new species, and 248 (77.5%) contain the descriptions of one or two, i.e., 77.5% of all papers contribute to the naming of just 33.3% of the species. This situation may reflect the pressure for publication, especially on postgraduate or untenured younger taxonomists. At the opposite extreme, 34 papers (10.6%) alone contain the descriptions of more than half the species (467 species, i.e., 51.3%). A reasonable assumption would be that short papers describing single new species are the work of single authors, whereas major papers with many new species are the result of collaborative work by several authors. In fact, an examination of the distribution of article-author pairs shows that 43.5% of papers describing one or two new species are co-authored by two or more authors (average 2.3 authors), whereas 38.2% of papers with five or more new species have more than one author (average 1.4 authors). Co-authorship of single species descriptions may reflect collector-describer and/or amateur-professional collaboration. To summarize, the description of new species of Recent mollusk takes place principally in two kinds of publications: (a) many small, scattered papers with a large number of co-authors, containing the descriptions of one or two new species; (b) a few major papers, mostly single-authored, containing the descriptions of 15 or more new species.

Table 6

Naming activity on new Recent mollusk species, as a percentage of the total output, in the top 14 countries compared with their scientometric weight in general biology (after Braun et al., 1995).

	1977–78		1992–93		Scientometric weight	
	%	Rank	%	Rank	%	Rank
Australia	2.3	11	9.7	3	3.3	8
Austria	9.2	3	0.7	13	0.4	26
Belgium	2.4	10	2.4	11	0.8	16
France	3.1	9	10	2	4.7	6
Germany	11.1	2	9.1	4	5.8	5
Italy	1.9	12	4.7	7	2.1	9
Japan	7.6	4	8.8	5	7.0	3
Netherlands	7.5	5	7.1	6	2.1	10
New Zealand	6.3	7	0.6	14	0.6	21
South Africa	3.9	8	1.8	12	0.8	17
Spain	1.7	13	4.3	8	1.8	12
United Kingdom	1.5	14	2.5	10	7.7	2
USA	23.2	1	20.3	1	36.5	1
ex USSR	6.6	6	4.3	8	4.0	7

Descriptive malacology has had a long history of interaction with amateurs, and I have therefore evaluated their involvement in the naming of new molluscan species. For this purpose, I have followed Coan (1988) in classifying as amateur anyone who is not paid specifically for his/her work in malacology. In doing so, I have have found it difficult to ascertain the professional position of some authors and, despite advice from colleagues, errors may have crept into my counts. Authors who are researchers or even taxonomists in other fields of science have had their contributions counted with those of amateurs. A number of professional malacologists remain active after their retirement, so that in one sense they are not "paid to study mollusks." I have, however, considered their contributions with those of professionals. In the case of co-authored papers, I have considered only the professional situation of the first author. In a sample of 931 names published in 1977–1978, 265 species (28.5%) were described by amateurs. In a second sample of 909 names published in 1992–1993, 251 species (27.6%) were described by amateurs. Despite the uncertainties mentioned above, this result shows that amateurs play a very significant role in the inventorying and naming of new mollusk species. Although I have

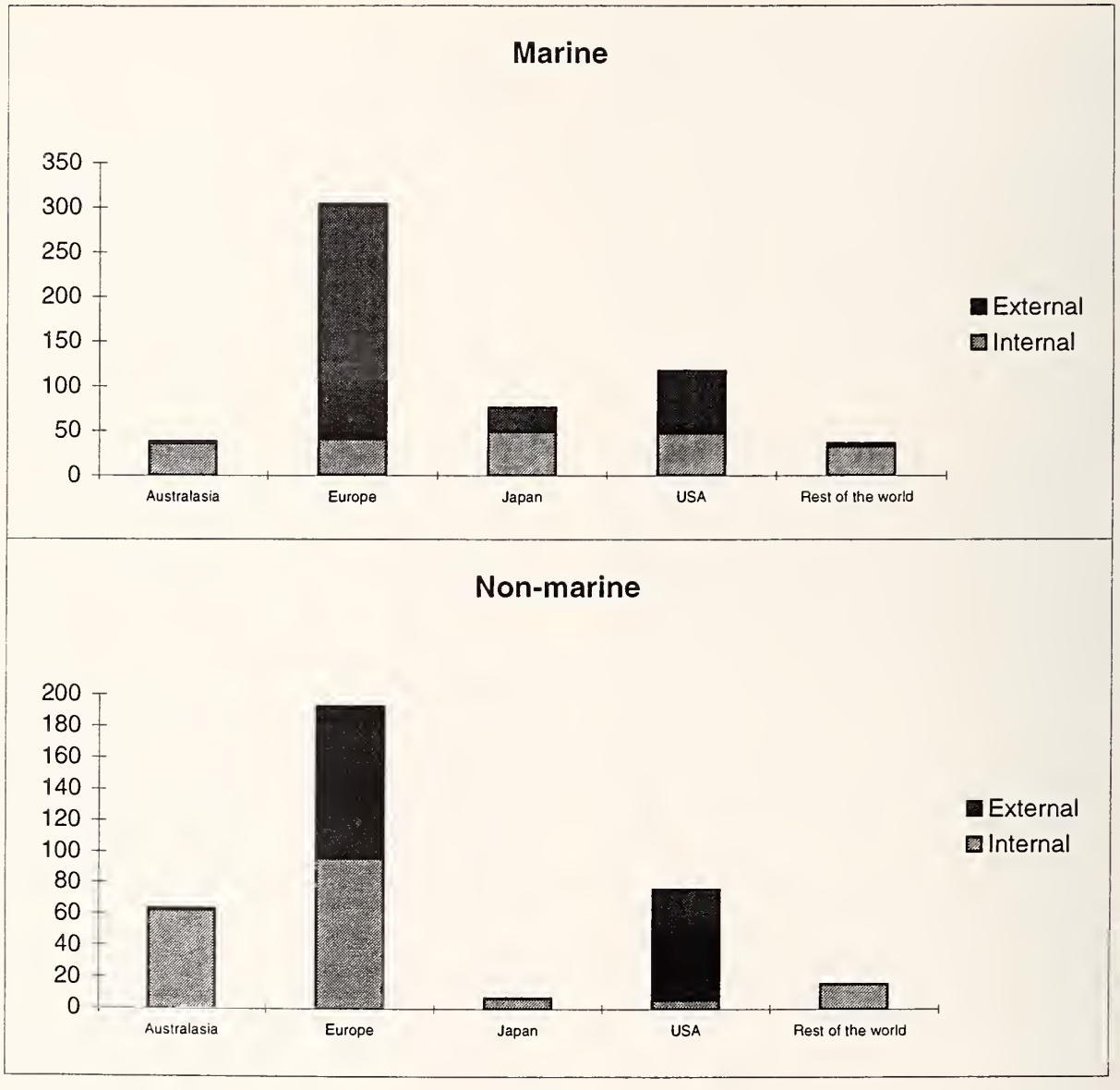

Figure 3

The efforts of malacologists from different parts of the world to describe new species from their own region (internal activity) and from regions other than their own (external activity).

not attempted a precise evaluation, it is likely that the contributions of retired professionals and amateurs pooled together may reach the 50% mark. The diversity of professional positions of authors of new species might be viewed as healthy in that people from different backgrounds take an interest in inventorying molluscan biodiversity. But the important contribution of amateurs and retired professionals may also be taken, despite some official statements on the importance of inventories, as a sign of the low esteem of alpha-taxonomy by many academic institutions and funding agencies.

Where Are Descriptions of New Species Published?

I have recognized four main categories of publication outlet: malacological journals, institutional (museums, universities, etc.) journals, journals published by learned societies and corporate publishers, and other publications (e.g., books). Based on the sample of 909 new Recent species described in 1992–1993, malacological journals form the main category, with nearly half (47.7%) of the new species contained in 28 serials (Table 7). Six of these (*Venus*, *La Conchiglia*, *Archiv für Molluskenkunde*, *Nauti-*

Table 7

Publication outlets used for descriptions of new Recent species. Sample: 909 names published in 1992–93.

Malacological journals	47.7%
Institutional journals	21.7%
Other journals	22.1%
Other publications (books)	8.5%

lus, Apex and *The Veliger*) are the malacological journals most frequently used for descriptions of new species, concentrating 28.6% of the new species, although no single journal has more than 8% of the total.

Inventorying the Biosphere

To visualize the effect of the current activity on the global inventorying of mollusks, I have charted the progress of knowledge on various groups of mollusks since Linnaeus (1758). Taking the current number of known species as a reference, I have plotted the number of species known at the end of every decade since 1758 as a percentage of that total (Figure 4) for selected groups of mollusks (Table 8), with different accessibility and different levels of interest to amateur malacologists.

Cypraeidae and the hydrobiid subfamily Cochliopinae might serve as examples to characterize patterns in inventories. The family Cypraeidae has been included because it is probably the mollusk group with the longest tradition for scientific inventorying, even in pre-Linnaean days. Not unexpectedly, the 50% mark of cowrie inventorying was reached as early as the 1820s, and a plateau phase has lasted since 1850. Quite another pattern is shown by the Cochliopinae, a group of small to minute snails living in specialized freshwater and brackish habitats. In 1830, when already half of the cowries were known, only two species of Cochliopinae, representing 0.7% of the total number of species known today, had already been described. The 50% mark of Cochliopinae inventorying was reached in the 1930s. The curve is still steeply ascending, and it seems quite impossible from the graph to predict the number that will be finally reached when the inventory of Cochliopinae has been reasonably completed. In fact, the recent taxonomic literature abounds with examples demonstrating the inadequacy of mollusk inventories in many parts of the world (Table 9).

One frustrating conclusion from results of this kind is that they do not help reach an irrefutable estimate on the number of mollusk species in the biosphere. In a recent review of organism inventory (Hammond, 1995), Mollusca was singled out as a group where "the number of described species currently accepted is particularly problematic, with quoted figures ranging from some 45,000 to 150,000."

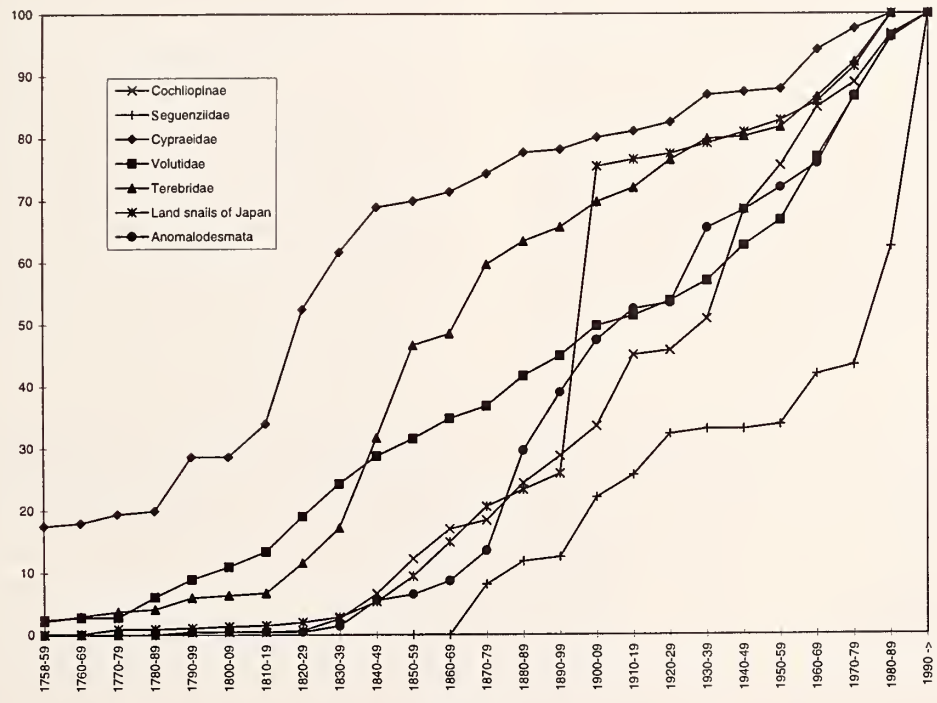

Figure 4

Progression of species inventorying in selected groups of Recent mollusks since 1758, plotted as a percentage of the known number of species (1995 = 100%). Only species currently recognized as valid are considered. Sources: see Table 7.

Table 8

Materials used to establish curves illustrating the progress of species inventorying since 1758. Results see Figure 4.

Taxon	No. known species	Source	Habitat	Interest to amateurs
Seguenziidae	136	Marshall, 1991	marine, 150–6000 m	nil
Cochliopinae	271	Hershler & Thompson, 1992	freshwater	nil
Cypraeidae	206	Lorenz & Hubert, 1993	marine, 0–30 m	very high
Volutidae	247	Poppe & Goto, 1992	marine, 0–500 m	high
Terebridae	268	Bratcher & Cernohorsky, 1987	marine, 0–200 m	low
Land snails of Japan	733	Minato, 1988	terrestrial	low
Anomalodesmata	415	Poutiers & Bernard, 1995	marine, 200–5000 m	nil

The Sources of the New Species

The steady naming activity results in part from application of new techniques (e.g., scanning electron microscopy, scuba diving, research submersibles), but also to a very large extent from a continuation of classical biological exploration, using the same methods as the generations before us. Despite the emphasis on cellular and molecular approaches in modern curriculums, very few new mollusk species have been *established* by research involving such new characters (e.g., Burch 1972; Murphy 1978; Gofas & Backeljau 1994; Bogan & Hoeh, 1995). More frequently, molecular characters are used *a posteriori* to evaluate the distinctness of cryptic taxa initially segregated on the basis of morphology (e.g., Backeljau et al. 1994; Kojima et al. 1995, reviewed by Davis 1994). In fact, the vast majority of new species named in the last few decades were recognized and described based on morphological characters.

A remarkable characteristic of marine mollusk inventorying of the last 30 years is the phenomenal comeback of amateur interest in collectable seashells. The number of known specimens of *Conus gloriamaris* Chemnitz, 1777, can be used as an example of the change in scale of collecting effort: this number has increased from a total of approx. 40 specimens known before 1968, to over 30 collected each year after 1968 (Poppe, personal communication), i.e., about three orders of magnitude. The increasing demand for collector items has elicited the availability of material from new or little known collecting grounds all over the world, particularly in the tropics. Despite the very narrow interest area of most amateurs, amateur malacology has generated descriptions, not only of new, showy species by non-professionals, but of all kinds of mollusks by amateurs and professionals alike, based on diverse and abundant material brought together by commercial dealers and enthusiast collectors.

The hydrothermal vents and cold seeps represent a spectacular example of a recently explored environment. The mollusk fauna associated with these habitats is remarkable in terms of novelty of species (nearly all were unnamed) and relationships (new families or superfamilies). However, it is not particularly diverse. A little more than 100 species have been described since 1981 (Warén & Bouchet, 1993), which represents a rather insignificant proportion of the global mollusk naming effort. In fact, the continued exploration of the ambient deep sea (below 200–300 m), although much less popular with the media, is yielding considerably more new species. Even in the North-East Atlantic, probably the best explored and inventoried of deep-sea basins, the proportion of new species named in the last 20 years exceeds 20% of the total fauna. New deep-

Table 9

Examples of papers containing the descriptions of large numbers of new Recent mollusk species.

Author	Taxon/Region	Species covered	New species
Salvini-Plawen, 1978	Solenogastres Antarctic	90	75
Kilburn, 1988	Turridae South Africa	71	42
Marshall, 1991	Seguenziidae New Caledonia	55	50
Vermeulen, 1991, 1994	Diplommatinidae Borneo	81	46
Ponder et al., 1993	Hydrobiidae Australia	64	51
Solem, 1993	Camaenidae Australia	65	39
Fischer-Piette et al., 1994	Pulmonata Madagascar	334	92
Rudman, 1995	Chromodorididae New Caledonia	*	11
Cosel, 1995	Bivalves West Africa	*	51

* Only new species described in paper.

sea species result from government-funded expeditions, mostly in South Africa (Kilburn & Herbert, 1995), the North Atlantic, the North Pacific, New Zealand, and New Caledonia (Richer de Forges, 1990); as by-products of commercial fishing in the Philippines, Somalia, and the Caribbean; or a combination of both research and commercial fishing, as in Japan and Australia.

In the last few decades, an extraordinary biological, anatomical, and ecological diversity of marine micromollusks has been revealed. For example, in Europe, the shallow-water mollusk fauna was reputed to be completely inventoried since the turn of the century until, rather unexpectedly, new species started to be named and described in the late 1960s. Since then, several hundred new species have been named, but few are larger than 10 mm, and most are smaller than 5 mm. Japan, the Caribbean, the Mediterranean, Australia, and New Zealand are regions where many new micromollusks have been described. During the same period, taxonomic research on nudibranchs has been revolutionized by the advent of SCUBA diving and color photography, eventually opening new areas of interest to dedicated amateurs and divers. The main geographical sources of new species of sea slugs have been Australia, Japan, Central America (both Panamic and Caribbean), the Mediterranean, and Brazil.

With regard to freshwater faunas, the study of waterborne diseases has maintained a steady level of malacological research in tropical regions. Although much of this research is non-taxonomical, the inventorying of freshwater mollusks has progressed in Africa, Southeast Asia, and China, clearly as a consequence of medical and parasitological programs. Hydrobioids certainly represent the least known segment of freshwater mollusk faunas, because they live in groundwater, springs and resurgences, caves, etc. and require specialized collecting. Interest in hydrobioids is being maintained at a rather high level, with speciose radiations recently described from Australia, southern Europe, Turkey, tropical China and Indochina, and the United States.

Inventorying of land snail faunas has progressed unevenly. The 1960s were a continuation of the colonial era, with northern hemisphere malacologists active in the Andes, Madagascar, Africa, and the Middle East. More recently, publication of major monographs on the Endodontoidea of the Pacific Islands and the Camaenidae of Australia rightly focuses our attention on the Australasia-Pacific region, which is the only tropical region to have experienced an acceptable level of land snail inventorying. New species have also been named from southern subtropical Japan, its offshore islands, and Taiwan. The most unexpected developments, however, have come from the Palearctic region, where numerous new species have been discovered and described in the Atlantic archipelagoes, the Balkan area and the Aegean archipelagoes, Turkey, the Caucasus, and the Tian-Shan mountain ranges of Central Asia. By contrast, vast areas of Central and West Africa, the tropical Andes, Brazilian Atlantic forest, and most of the Oriental region have remained outside the stream of mollusk inventorying.

PERSPECTIVES

The results amply demonstrate that the inventory of molluscan biodiversity is far from achieved. Consequently, there is ample justification for high levels of research time, institutional support, and journal space to continue to be devoted to alpha-taxonomy. As an example, based on preliminary examination of sublittoral (below 100 m) material dredged in New Caledonia in 1984–1994, Bruce Marshall and I estimate that about 80% of the 2000+ species are still undescribed. Considering that approx. 190 valid new marine species (310 nominal species/synonymy ratio 1.62) are described each year worldwide, there remains an unlimited perspective for alpha-taxonomy. The era of discovery of very large species (e.g., *Turbinella laffertyi* Kilburn, 1975, size 280 mm, or *Tridacna tevoroa* Lucas, Ledua & Braley, 1990, size 500 mm) is however probably coming to an end. Micromollusks, deep-sea faunas, and the non-marine and marine tropics obviously constitute the main reservoirs of unknown species, and the Indo-Pacific, both in shallow and deep water, is likely to remain a major frontier for many decades.

The most distressing perspective is the loss of knowledge about and attention given to tropical non-marine faunas. Europe, North America, and Japan contain most of the experts on land and freshwater mollusks available worldwide, but most of this work is directed toward their local faunas, although the Palearctic and Nearctic are already the best inventoried. Despite declarations on the necessity to preserve the biological diversity of our planet, it is certain that many tropical land and freshwater snail radiations will become extinct through loss of habitat before they have been described, even before they have been collected (Emberton, 1995). Regrettably, there is no passive method for collecting land snails comparable to the trapping and/or knock-out fogging methods used to collect many arthropods that can be efficiently operated by general ecologists and other non-specialists. Surveys and collections of land and freshwater mollusks can only be done by experienced collectors, and it is important that more sensitive and threatened geographical areas are properly surveyed and inventoried before their faunas have been devastated like those, for example, of Hawaii (Solem, 1990) or Rodrigues Island (Griffiths, 1994).

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